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Idaho
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A Comprehensive Inventory of Radiological and Nonradiological Contaminants in Waste Buried or Projected to be Buried in the Subsurface Disposal Area of the INEL RWMC During the Years 1984-2003

Volume 1

Lockheed
Idaho Technologies Company

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Idaho National Engineering Laboratory
Lockheed Idaho Technologies Company
Idaho Falls, Idaho 83415

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PREFACE

This report, *A Comprehensive Inventory of Radiological and Nonradiological Contaminants in Waste Buried or Projected to be Buried in the Subsurface Disposal Area of the INEL RWMC During the Years 1984–2003*, is composed of three volumes. Volume 1 consists of the main body of the report and Appendices A, C, D, E, F, and G. Appendix B, the complete printout of the inventory database, is provided in Volumes 2 and 3. Because of its size, distribution of Appendix B has been limited. A copy of the volumes containing Appendix B can be provided on request.

ABSTRACT

This report presents a comprehensive inventory of the radiological and nonradiological contaminants in waste buried or projected to be buried from 1984 through 2003 in the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC) of the Idaho National Engineering Laboratory. The project to compile the inventory is referred to as the recent and projected data task. The inventory was compiled primarily for use in a baseline risk assessment under the Comprehensive Environmental Response, Compensation, and Liability Act. The compiled information may also be useful for environmental remediation activities that might be necessary at the RWMC. The information that was compiled has been entered into a database termed CIDRA—the Contaminant Inventory Database for Risk Assessment.

The inventory information was organized according to waste generator and divided into waste streams for each generator. The inventory is based on waste information that was available in facility operating records, technical and programmatic reports, shipping records, and waste generator forecasts. Additional information was obtained by reviewing the plant operations that originally generated the waste, by interviewing personnel formerly employed as operators, and by performing nuclear physics and engineering calculations. In addition to contaminant inventories, information was compiled on the physical and chemical characteristics and the packaging of the 99 waste streams.

The inventory information for waste projected to be buried at the SDA in the future was obtained from waste generator forecasts. Additional information was obtained by interviewing waste generator personnel and by performing nuclear physics and engineering calculations.

The contaminant inventories were developed in the form of best estimates. Upper and lower bounds were also formulated by evaluating the methods by which contaminant quantities were estimated.

The completeness of the contaminant inventories was confirmed by comparing them against inventories in previous reports and in other databases, and against the list of contaminants detected in environmental monitoring performed at the RWMC.

This report is a follow-on to a previous report[a] that covered waste buried during the years 1952 through 1983. The methodologies used in the two reports are essentially identical. Taken together, the two reports encompass the waste buried or projected to be buried in the SDA from 1952 through 2003.

a. *A Comprehensive Inventory of Radiological and Nonradiological Contaminants in Waste Buried in the Subsurface Disposal Area of the INEL RWMC During the Years 1952–1983*, INEL-95/0310, Rev. 1, formerly EGG-WM-10903, Lockheed Idaho Technologies Company, August 1995.

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Program Management		Douglas K. Jorgensen Rozanne M. Huntley Thomas A. Matzen
Technical Lead		Thomas H. Smith Cynthia E. Klassy
Data Gatherers	TAN	Henry K. Peterson
	TRA	Yale D. Harker Cecilia R. Amaro
	ICPP	Donald W. Rhodes
	NRF	Patrick R. Leonard
	ANL-W	Roy P. Grant, ANL-W
	Other	Donald W. Rhodes
Uncertainty Analysis		Jeffrey J. Einerson
Database and Application Development		Cathy J. Barnard Melinda J. Schlafman Michael R. Groh Connee D. White
Environmental Monitoring Comparisons		Tiffany A. Bensen Cynthia E. Klassy
Comparisons Against Other Documents and Databases		Donald E. Kudera Thomas H. Smith
Technical Editors		DeAnne Casperson Gayle C. Black

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EXECUTIVE SUMMARY

Introduction and Background

This report documents the compilation of a comprehensive inventory of radiological and nonradiological contaminants in waste buried in the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC) of the Idaho National Engineering Laboratory (INEL). The inventory was compiled primarily for use in a baseline risk assessment (BRA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The project to compile the inventory is referred to as the recent and projected data task (RPDT).

The RWMC, located in the southwest portion of the INEL, is a solid radioactive waste disposal site. It consists of the 38.85-ha SDA, the 22.7-ha Transuranic Storage Area, and the Administrative Area.

The inventory covers the waste buried and projected to be buried in the SDA from 1984 through 2003. The SDA disposal units covered in this report include the nontransuranic-contaminated waste pits and soil vault rows open during the period of interest.

Waste in the Transuranic Storage Area is not included in this inventory because it is stored aboveground. Waste disposed of in the SDA before 1984 is excluded because it is covered in the previous report covering the years 1952–1983.[b]

The inventory addresses radioactive waste, hazardous substances per CERCLA [which encompass hazardous waste per the Resource Conservation and Recovery Act (RCRA)], and mixed waste.

This task built upon the inventories in previous reports and databases by adding several types of additional information that are needed for the BRA:

- A more comprehensive inventory of nonradiological contaminants

- Identification of specific radionuclides previously listed under generic names [e.g., mixed fission products (MFP) or mixed activation products (MAP)]

- Physical and chemical forms of the contaminants and of the host waste streams

- Uncertainties in the contaminant quantities.

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b. *A Comprehensive Inventory of Radiological and Nonradiological Contaminants in Waste Buried in the Subsurface Disposal Area of the INEL RWMC During the Years 1952–1983*, INEL-95/0310, Rev. 1, formerly EGG-WM-10903, Lockheed Idpaho Technologies Company, August 1995.

This inventory was compiled pursuant to regulations and agreements related to CERCLA. A Federal Facility Agreement and Consent Order (FFA/CO) for the INEL was signed by the U.S. Department of Energy, U.S. Environmental Protection Agency, and State of Idaho Department of Health and Welfare to protect human health and the environment. One of the INEL waste area groups (WAGs) defined under the FFA/CO is WAG-7, the RWMC.

Under the CERCLA implementing regulations of 40 CFR 300.430 (d)(2), the lead agency is required to "characterize the nature of and threat posed by the hazardous substances and hazardous materials and gather data necessary to assess the extent to which the release poses a threat to human health or the environment . . . ." The information collected is to cover ". . . the general characteristics of the waste, including quantities, state, concentration, toxicity, propensity to bioaccumulate, persistence, and mobility" and "the extent to which the source can be adequately identified and characterized."

Per guidance in the National Contingency Plan under CERCLA, a human health BRA will be performed for the SDA. The inventory developed here and in the previous report will be used to help determine the source term for the BRA. As currently planned, the inventory will also be used in the WAG-7 BRA for the comprehensive remedial investigation/feasibility study.

In addition to helping determine the BRA source term, the inventory information compiled here and in the previous report has other potential uses. Examples are evaluating remedial alternatives (should remediation be required), assessing health and safety hazards to workers, and identifying potential operational problems.

Methodology for Data Collection and Compilation

The Challenge

The approach for compiling the inventory information had to reflect the complex nature of the waste disposal situation at the SDA. When disposal at the SDA began 42 years ago, requirements and practices did not include the current requirements for waste characterization, so complete information about the waste was not obtained when it was generated and disposed of. Although the collection of information for newly generated waste improved gradually, there were still some information gaps during the 1984–1993 time period.

The disposal area is large and the waste is varied, so drilling and sampling to determine the contaminant inventory is not feasible. Even a massive drilling and sampling campaign would not result in an inventory in which high confidence could be placed, because of the heterogeneity of the waste.

Information about and inventory compilations of the waste buried in the SDA have been produced in previous efforts for various uses. Some of the compilations have been entered into databases, such as the Radioactive Waste Management Information System (RWMIS). The previous compilations contain useful information, but they have limitations. For example, RWMIS problems include the following. Some textual descriptions are generic (e.g., "plant waste") and do not provide insight into the actual contents of the waste. RWMIS contains very little information concerning nonradiological contaminants in the waste. The radionuclide listings in RWMIS have problems, such as (a) entries with only one radionuclide identified, e.g., Pu-239, whereas knowledge of the waste-generating process indicates that other radionuclides must also be present; (b) entries with only the element specified, e.g., uranium, with no designation of a particular radionuclide; (c) entries with only generic radioactivity terms MAP or MFP identified, with no designation of particular radionuclides; and (d) entries with only one fission product identified, e.g., Cs-137, whereas others must also be present.

Most previous compilations were derived solely from shipping records. Many addressed only the radiological contaminants in the waste. It was concluded that the existing compilations, though very useful, were not adequate to support the BRA.

The Approach

A different approach to compile the inventory information was devised. The approach emphasized the use of information about the processes that generated the waste, supplemented by information from reports, shipping records, and databases. First, the facilities that generated the SDA waste were divided into six groups, as follows: Test Area North (TAN), Test Reactor Area (TRA), Idaho Chemical Processing Plant (ICPP), Naval Reactors Facility (NRF), Argonne National Laboratory—West (ANL-W), and "other" generators (this designation includes all other onsite facilities, all other offsite facilities, and decontamination and decommissioning programs). Six lead data gatherers were then appointed to direct the compilation of information on the waste from the six generators. In nearly every case, each lead data gatherer had worked previously at the waste generator location whose information he was assigned to collect, and each was familiar with the operational activities that generated the waste.

Figure S-1 depicts the flow of information in this approach. The rectangles represent items of information, and the ovals represent technical activities performed on the information. Several sources of information were used by the data gatherers: process knowledge and plant operating records, inventory and other technical reports, engineering and nuclear physics calculations, shipping records and databases thereof, interviews with current and past plant operating personnel, and waste generator forecasts. For each of the waste generators, varying uses were made of these sources, depending on the availability of each and the nature of the waste.

The waste from a given facility of a given generator was subdivided into several waste streams. Basically, a waste stream was defined so as to reduce the nonhomogeneity within the stream. For example, one stream consisted of all of the beryllium reflectors from TRA.

A standardized, five-page data form was used to record the information for each of the 99 identified waste streams. The form requested the following information: the waste generator, the building, and the assigned number of the waste stream from that building; the physical and chemical form of the waste stream itself; the quantities (including uncertainties) and the physical and chemical forms of any nonradiological contaminants and radiological contaminants in the stream; and the source(s) and reliability of the information.

After the information was entered onto data forms, it was subjected to qualification as shown in Figure S-1 and entered into the new Contaminant Inventory Database for Risk Assessment (CIDRA).

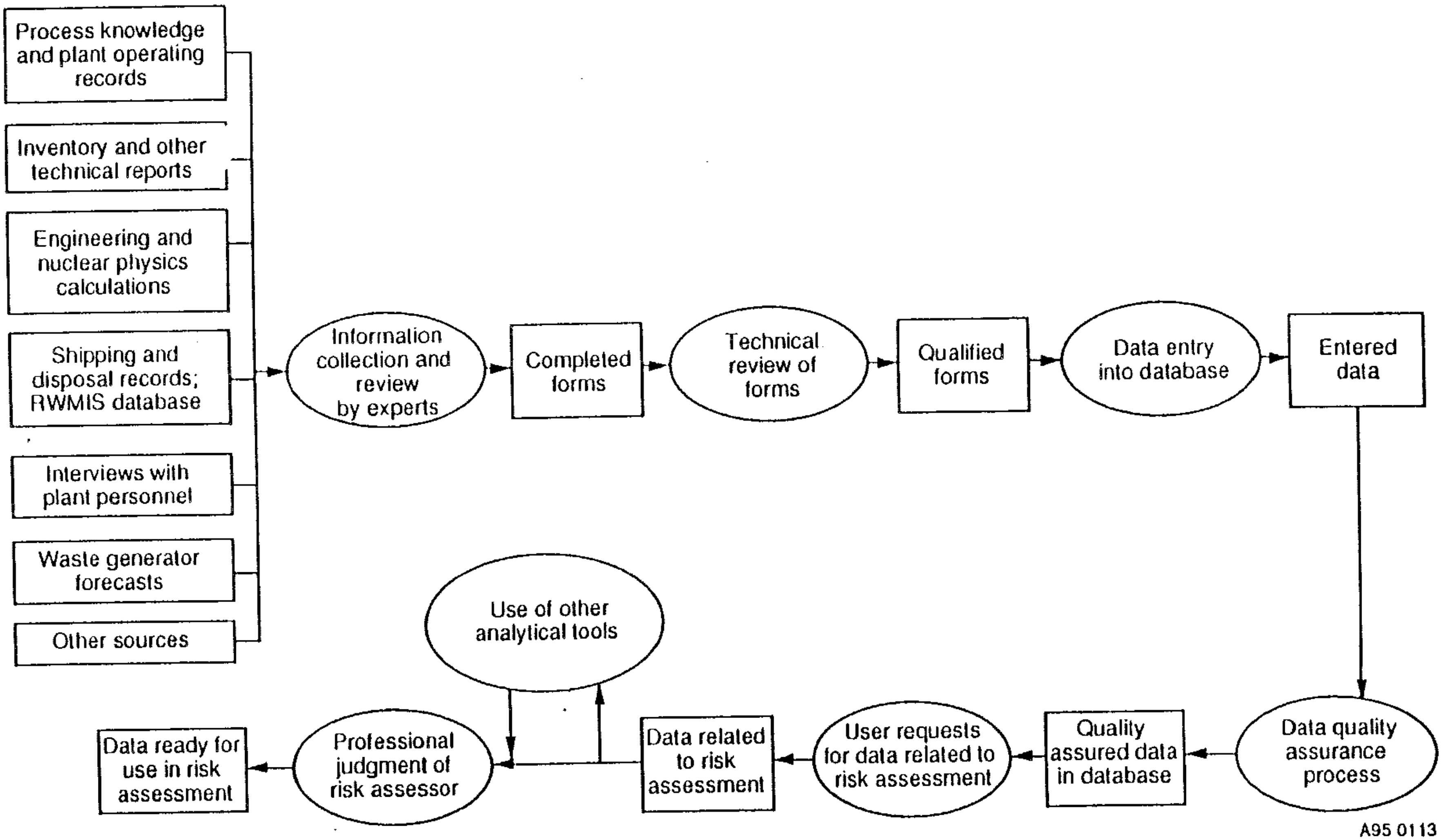

Figure S-1. Approach for information flow in developing the inventory.

Results

An appendix to this report, in several volumes, contains a complete printout of the information in the CIDRA database.

Tables S-1 and S-2 list the total best-estimate quantities of each contaminant, covering all waste streams from all generators for the recent (1984–1993) period. Similarly, Tables S-3 and S-4 list the total best-estimate quantities for all waste streams from all generators for the projected (1994–2003) period. Upper and lower bounds are also given. Tables S-1 and S-3 list the nonradiological contaminants, in terms of grams (g). Tables S-2 and S-4 list the radiological contaminants, in terms of curies (Ci) at the time of disposal. Similar tables are presented in this report for each waste generator.

All inventories in this report are given to only two significant digits. Specification of more significant digits would give an erroneous impression of the accuracy inherent in the inventories.

The uncertainties in the contaminant inventory were evaluated as follows. Best estimates of the annual or total quantities of each contaminant for each waste stream were made by the data gatherers. Upper and lower bounds, analogous to 95% confidence limits, accompany the best estimates. When possible, the bounds are based on actual measurements and on the experience and knowledge of the data gatherers. When not possible, generic error bounds were constructed by propagation of known biases and expected uncertainties. Using standard statistical techniques, the errors in annual quantities for individual waste streams were propagated to obtain upper and lower bounds on the total quantity for each contaminant. This error-propagation procedure is programmed into CIDRA. For the projected waste, this effort included estimating the uncertainty in the waste generator forecasts.

A bias in many of the waste records is due to the use of the Geiger-Müller (G-M) counter survey method to estimate the quantities of radiological contaminants in the waste containers. Radioactivity data believed to have been obtained by this method were corrected in the CIDRA inventory. The correction was based on extensive study of the results of previous evaluations on the accuracy of that method, using laboratory mock-ups and actual waste containers. The overall correction, which is a product of three multiplicative factors, is a downward revision by a factor of 2 for the affected contaminants and waste streams.

The accuracy of the waste generator forecasts, by which the radioactivity in future waste was projected, was evaluated. Comparison of past forecasts against later disposals showed that the forecasts have been biased upward by, on the average, a factor of 4. A correction was applied in CIDRA to projections that were based on the waste generator forecasts.

Table S-1. Inventory of nonradiological contaminants (listed alphabetically) from all generators for the years 1984–1993.

CAS number	Chemical	Best estimate (g)	Lower bound	Upper bound
7440-38-2	Arsenic	5.0E-01	3.0E-01	7.9E-01
1332-21-4	Asbestos	2.3E+06	1.6E+06	3.2E+06
7440-41-7	Beryllium	6.3E+06	6.3E+06	6.4E+06
7440-43-9	Cadmium	1.8E+00	1.5E+00	2.0E+00
7440-47-3	Chromium	2.9E+01	1.7E+01	4.6E+01
7440-50-8	Copper	2.3E+04	7.9E+03	5.2E+04
7439-92-1	Lead	9.8E+07	8.2E+07	1.1E+08
7439-97-6	Mercury	2.0E+00	1.2E+00	3.2E+00
1314-23-4	Zirconium oxide	4.5E+03	3.9E+03	5.3E+03

Table S-2. Inventory of radiological contaminants (listed alphabetically) from all generators for the years 1984–1993 (activity at time of disposal).

Radionuclide	Best estimate (Ci)	Percent of total (%)	Lower bound	Upper bound
Ag-108m	1.1E-07	<0.05	5.5E-10	7.7E-07
Ag-110	1.9E+00	<0.05	1.0E-02	1.4E+01
Ag-110m	1.8E-02	<0.05	1.3E-04	1.2E-01
Am-241	3.7E+00	<0.05	2.7E-02	2.6E+01
Au-198	2.4E-02	<0.05	1.3E-03	1.2E-01
Ba-137m	4.6E+00	<0.05	3.0E+00	6.8E+00
Ba-140	2.4E+00	<0.05	4.1E-02	1.6E+01
Br-82	1.0E-03	<0.05	5.1E-06	7.3E-03
C-14	4.0E+01	<0.05	4.1E-01	2.8E+02
Cd-109	1.1E-02	<0.05	5.6E-05	7.9E-02
Ce-139	3.0E-04	<0.05	1.5E-06	2.2E-03
Ce-141	2.9E+00	<0.05	5.4E-02	1.8E+01
Ce-144	2.1E+02	<0.05	3.9E+01	6.8E+02
Cm-242	8.8E-02	<0.05	6.8E-04	6.2E-01
Cm-244	7.6E-02	<0.05	5.2E-04	5.4E-01
Co-57	1.5E+00	<0.05	8.6E-02	7.8E+00
Co-58	2.0E+05	7.1	2.5E+04	7.5E+05
Co-60	1.4E+06	50.8	9.3E+05	2.0E+06
Cr-51	4.7E+04	1.7	5.4E+03	1.9E+05
Cs-134	1.4E+02	<0.05	6.1E+00	7.7E+02
Cs-137	3.1E+03	0.1	1.1E+03	7.0E+03
Eu-152	4.1E+00	<0.05	2.0E-01	2.2E+01
Eu-154	3.3E+00	<0.05	3.5E-01	1.4E+01
Eu-155	3.9E+01	<0.05	5.1E-01	2.6E+02
Fe-55	1.6E+05	5.7	1.4E+05	1.8E+05
Fe-59	1.5E+04	0.5	1.5E+03	6.0E+04
Gd-153	1.3E+00	<0.05	1.1E-02	9.2E+00

Table S-2. (continued).

Radionuclide	Best estimate (Ci)	Percent of total (%)	Lower bound	Upper bound
H-3	3.0E+05	10.7	1.0E+05	6.8E+05
Hf-181	3.4E+03	0.1	3.0E+03	3.9E+03
Hf-175	2.8E+03	0.1	2.5E+03	3.2E+03
I-129	2.1E-03	<0.05	3.1E-05	1.4E-02
I-131	1.1E-01	<0.05	2.2E-03	7.2E-01
I-132	1.0E+00	<0.05	5.6E-03	7.3E+00
I-133	1.5E-03	<0.05	7.6E-06	1.1E-02
In-113m	8.2E-02	<0.05	4.4E-03	4.2E-01
Ir-192	6.6E-01	<0.05	5.4E-03	4.6E+00
La-140	2.8E+00	<0.05	4.9E-02	1.8E+01
Mn-54	1.2E+05	4.2	1.2E+04	4.8E+05
Mn-56	1.3E+00	<0.05	6.6E-03	9.5E+00
Mo-99	2.3E-02	<0.05	1.6E-04	1.6E-01
Na-22	5.4E-01	<0.05	3.6E-02	2.6E+00
Na-24	2.7E+00	<0.05	2.0E-02	1.9E+01
Nb-94	2.0E-01	<0.05	8.9E-04	1.5E+00
Nb-95	3.8E+03	0.1	2.6E+03	5.4E+03
Ni-59	1.4E+03	<0.05	1.1E+03	1.8E+03
Ni-63	4.8E+05	17.2	4.3E+05	5.2E+05
Np-237	3.7E-03	<0.05	2.2E-05	2.7E-02
Pm-147	2.4E+00	<0.05	1.2E-02	1.7E+01
Pr-144	1.1E+02	<0.05	1.9E+01	3.7E+02
Pu-238	3.6E-01	<0.05	8.5E-03	2.2E+00
Pu-239	2.4E+00	<0.05	2.4E-01	1.0E+01
Pu-240	5.7E-02	<0.05	2.4E-03	3.1E-01
Pu-241	1.7E+01	<0.05	1.0E-01	1.2E+02
Pu-242	1.2E-08	<0.05	6.0E-11	8.9E-08

Table S-2. (continued).

Radionuclide	Best estimate (Ci)	Percent of total (%)	Lower bound	Upper bound
Ra-226	1.1E+00	<0.05	8.7E-01	1.4E+00
Re-188	9.3E-03	<0.05	4.7E-05	6.8E-02
Rh-106	6.1E+01	<0.05	1.1E+01	2.0E+02
Ru-103	1.9E-01	<0.05	2.5E-03	1.3E+00
Ru-106	6.4E+01	<0.05	1.3E+01	2.0E+02
Sb-124	1.1E-02	<0.05	2.4E-04	7.1E-02
Sb-125	2.9E+03	0.1	2.4E+03	3.4E+03
Sc-46	5.0E+01	<0.05	2.6E-01	3.6E+02
Se-75	4.5E-02	<0.05	8.0E-04	2.9E-01
Sn-113	2.4E+01	<0.05	2.1E-01	1.7E+02
Sn-117m	1.2E+02	<0.05	6.1E-01	8.7E+02
Sn-119m	8.8E+03	0.3	7.6E+03	1.0E+04
Sr-89	3.0E+00	<0.05	3.7E-02	2.0E+01
Sr-90	5.8E+02	<0.05	4.4E+01	2.6E+03
Sr-91	4.4E-03	<0.05	2.2E-05	3.2E-02
Sr-92	1.6E-03	<0.05	8.2E-06	1.2E-02
Ta-182	1.8E+04	0.6	1.6E+04	2.0E+04
Tc-99	5.0E-01	<0.05	2.8E-03	3.6E+00
Te-125m	4.2E+01	<0.05	2.2E-01	3.0E+02
Te-132	5.6E-03	<0.05	3.3E-04	2.8E-02
Th-228	1.0E+01	<0.05	8.4E+00	1.2E+01
U-232	2.2E+00	<0.05	1.8E+00	2.7E+00
U-234	3.5E+00	<0.05	3.3E+00	3.7E+00
U-235	1.6E-01	<0.05	1.5E-01	1.6E-01
U-236	2.3E-03	<0.05	1.1E-03	4.1E-03
U-238	1.6E+00	<0.05	1.6E+00	1.7E+00
V-48	2.0E-01	<0.05	4.4E-03	1.2E+00

Table S-2. (continued).

Radionuclide	Best estimate (Ci)	Percent of total (%)	Lower bound	Upper bound
W-185	6.4E+03	0.2	5.6E+03	7.3E+03
Y-88	3.0E-03	<0.05	1.5E-05	2.2E-02
Y-90	2.0E+02	<0.05	3.5E+01	6.7E+02
Y-93	1.1E-01	<0.05	5.6E-04	8.0E-01
Zn-65	1.0E+03	<0.05	8.5E+00	7.2E+03
Zr-95	2.1E+03	0.1	1.4E+03	3.0E+03
Total	2.8E+06	99.6		

Table S-3. Inventory of nonradiological contaminants (listed alphabetically) from all generators for the years 1994–2003.

CAS number	Chemical	Best estimate (g)	Lower bound	Upper bound
7440-38-2	Arsenic	2.1E-01	1.2E-01	3.3E-01
1332-21-4	Asbestos	1.1E+06	4.2E+05	2.4E+06
7440-39-3	Barium	7.3E+00	4.3E+00	1.2E+01
7440-41-7	Beryllium	5.0E+07	5.0E+07	5.1E+07
7440-43-9	Cadmium	5.8E+00	3.8E+00	8.6E+00
7440-47-3	Chromium	1.9E+01	1.1E+01	3.0E+01
7439-92-1	Lead	1.6E+00	1.3E+00	2.0E+00
7439-97-6	Mercury	1.3E-02	1.1E-02	1.5E-02

Table S-4. Inventory of radiological contaminants (listed alphabetically) from all generators for the years 1994–2003 (activity at time of disposal).

Radionuclide	Best estimate (Ci)	Percent of total (%)	Lower bound	Upper bound
Ag-108	1.6E-01	<0.05	5.2E-03	9.4E-01
Ag-110m	9.7E-04	<0.05	5.2E-05	4.9E-03
Am-241	2.1E-01	<0.05	1.3E-02	1.0E+00
Au-198	1.6E-02	<0.05	9.0E-04	8.0E-02
Ba-137m	1.1E+00	<0.05	6.1E-03	8.0E+00
Ba-140	4.2E-02	<0.05	1.5E-03	2.4E-01
C-14	9.5E+01	<0.05	7.4E+00	4.3E+02
Ce-141	1.4E-01	<0.05	8.1E-03	6.7E-01
Ce-144	5.8E+01	<0.05	7.2E+00	2.3E+02
Cm-242	2.2E-01	<0.05	1.6E-02	1.0E+00
Cm-244	1.9E-01	<0.05	1.2E-02	9.3E-01
Co-57	1.2E-01	<0.05	4.5E-03	6.8E-01
Co-58	1.0E+05	2.7	5.9E+03	5.0E+05
Co-60	7.9E+05	21.0	3.1E+05	1.7E+06
Cr-51	2.6E+04	0.7	1.6E+03	1.3E+05
Cs-134	5.0E+00	<0.05	8.5E-01	1.7E+01
Cs-137	1.6E+03	<0.05	6.3E+02	3.3E+03
Eu-152	6.9E-01	<0.05	3.8E-02	3.5E+00
Eu-154	1.4E+00	<0.05	1.6E-01	5.5E+00
Eu-155	7.2E+01	<0.05	4.4E+00	3.5E+02
Fe-55	3.8E+04	1.0	1.7E+04	7.6E+04
Fe-59	8.1E+03	0.2	4.4E+02	4.1E+04
H-3	2.6E+06	70.4	1.3E+06	5.0E+06
Hf-181	1.6E-01	<0.05	8.8E-03	8.3E-01
I-129	5.1E-02	<0.05	6.2E-03	2.0E-01
I-131	2.5E-02	<0.05	1.5E-03	1.2E-01
In-113m	5.4E-02	<0.05	3.1E-03	2.7E-01

Table S-4. (continued).

Radionuclide	Best estimate (Ci)	Percent of total (%)	Lower bound	Upper bound
Ir-192	1.4E+00	<0.05	1.4E-01	5.7E+00
La-140	1.1E-01	<0.05	6.5E-03	5.4E-01
Mn-54	6.5E+04	1.7	3.5E+03	3.3E+05
Mo-99	2.4E-02	<0.05	1.3E-03	1.2E-01
Na-22	1.1E-01	<0.05	6.1E-03	5.5E-01
Nb-94	1.9E+00	<0.05	1.9E-02	1.3E+01
Nb-95	6.8E+03	0.2	2.2E+03	1.6E+04
Ni-59	1.9E+02	<0.05	1.9E+00	1.3E+03
Ni-63	6.9E+04	1.8	2.5E+04	1.5E+05
Np-237	1.7E-02	<0.05	4.3E-04	1.0E-01
Pr-144	2.6E+00	<0.05	2.5E-01	1.1E+01
Pu-238	4.1E-01	<0.05	2.6E-02	2.0E+00
Pu-239	4.2E-01	<0.05	2.7E-02	2.0E+00
Pu-240	4.5E-02	<0.05	3.0E-03	2.2E-01
Pu-241	4.6E+01	<0.05	3.0E+00	2.2E+02
Rh-106	3.9E-01	<0.05	3.2E-02	1.7E+00
Ru-103	1.6E-02	<0.05	8.8E-04	8.2E-02
Ru-106	4.0E-01	<0.05	3.4E-02	1.8E+00
Sb-124	2.4E-03	<0.05	1.3E-04	1.2E-02
Sb-125	4.1E+00	<0.05	3.7E-01	1.8E+01
Sc-46	3.7E-02	<0.05	2.0E-03	1.9E-01
Se-75	9.4E-03	<0.05	5.1E-04	4.8E-02
Sn-113	6.3E-02	<0.05	3.7E-03	3.1E-01
Sn-117m	3.4E-02	<0.05	2.0E-03	1.7E-01
Sr-89	5.4E-04	<0.05	2.9E-05	2.7E-03
Sr-90	8.2E+01	<0.05	1.1E+01	3.1E+02
Ta-182	7.6E+03	0.2	2.4E+03	1.8E+04

Table S-4. (continued).

Radionuclide	Best estimate (Ci)	Percent of total (%)	Lower bound	Upper bound
Tc-99	1.4E+00	<0.05	8.6E-02	6.7E+00
Te-132	2.9E-03	<0.05	1.6E-04	1.5E-02
U-234	5.0E-02	<0.05	3.1E-02	7.6E-02
U-235	1.7E-03	<0.05	1.3E-03	2.3E-03
U-236	6.0E-03	<0.05	2.9E-03	1.1E-02
U-238	5.2E-02	<0.05	3.2E-02	7.8E-02
Xe-133	5.0E-04	<0.05	2.7E-05	2.5E-03
Y-90	6.9E+01	<0.05	7.0E+00	2.9E+02
Zn-65	1.2E+00	<0.05	6.5E-02	6.1E+00
Zr-95	3.2E+03	0.1	1.0E+03	7.7E+03
Total	3.8E+06	100.0		

Observations and Conclusions

The observations and conclusions for the contaminants in the recent (1984–1993) and projected (1994–2003) waste are as follows:

- The combined use of many types of information sources—process knowledge, operating records, nuclear physics calculations, reports, interviews, shipping records, the RWMIS database, waste generator forecasts, and others—was essential to achieve the present degree of completeness of the recent and projected inventories.

- For nonradiological contaminants, the inventory information that could be located or deduced for the 1984–1993 and 1994–2003 periods from information sources and that is compiled in CIDRA is believed to be substantially complete.

- The number and quantities of nonradiological contaminants identified in or projected to be in the waste being disposed of in the SDA decreased dramatically after 1984. For most (but not all) of those nonradiological contaminants, the presence of the contaminant could cause the waste to be designated as hazardous per RCRA. Beginning in 1984, DOE was required to come into compliance with RCRA, so acceptance of mixed waste for disposal at the SDA was discontinued in April 1984. An exception was made for contaminated lead used as radiation shielding, which was allowed for disposal as late as December 31, 1987.

- For the radiological contaminants, the inventory information that could be located or deduced for the 1984–1993 and 1994–2003 periods from information sources and that is compiled in the new CIDRA database is believed to be substantially complete.

- A considerable effort was devoted to estimating the uncertainty in the quantities of nonradiological and radiological contaminants. For the projected waste, this effort included estimating the uncertainty in waste generator forecasts.

- A considerable effort was devoted to breaking down the generic radioactivity terms MAP, MFP, and unidentified beta/gamma-emitters for each generator so that a specific distribution of radionuclides would be available for the risk assessment.

- The predominant (by mass) nonradiological contaminants identified in the waste were as follows: for the 1984–1993 period—lead, beryllium, asbestos, copper, zirconium oxide, and chromium; for the 1994–2003 period—beryllium, asbestos, and chromium.

- The predominant (by radioactivity at the time of disposal) radiological contaminants identified in the waste were as follows: for the 1984–1993 period—Co-60, Ni-63, H-3, Co-58, Fe-55, Mn-54, Cr-51, Ta-182, and Fe-59; for the 1994–2003 period—H-3, Co-60, Co-58, Ni-63, Mn-54, Fe-55, and Cr-51.

- To confirm its substantial completeness, the compiled recent (1984–1993) inventory of radiological contaminants was compared against the corresponding inventory in the

RWMIS database. The results of these comparisons confirm that the current task has not overlooked any substantial radioactivity in the waste. The total activity in CIDRA (without the G-M correction) agrees with the total inventory in RWMIS to within the accuracy allowed by the use of two significant figures. For all of the principal, longer-lived radionuclides, the activity in CIDRA is similar to or larger than that in RWMIS.

- The total activities of the fission products differ between CIDRA and RWMIS by about 20%. This difference is less than the total random error for estimating the radioactivity in an individual waste shipment.

- The CIDRA value agrees with the RWMIS entry for tritium (H-3) to within the study precision of two significant figures. The H-3 is almost entirely in the beryllium reflectors from the TRA waste.

- The total activities of the activation products differ <1% between CIDRA and RWMIS.

- The activities of C-14, Tc-99, and I-129 in CIDRA are considerably larger than those in RWMIS. These radionuclides are important because of their very long half-lives and their relatively high mobility if released from the waste form. These radionuclides are very difficult to measure in waste shipments. The values in CIDRA were developed by means of nuclear physics calculations.

- As an additional confirmation of its completeness, the compiled nonradiological inventory for the 1984–1993 period was compared against the information found in previous reports. Very few studies have been performed on the nonradiological contaminants buried in the SDA in the recent period. Therefore, the comparisons were of limited value but identified no evidence that the new inventory was incomplete.

- As an additional confirmation of its completeness, the compiled radiological inventory for the 1984–1993 period was compared against the information found in previous reports. Only one report contained data for the recent period. Because the data were nearly identical to those in the RWMIS database, no detailed comparison was carried out.

- The compiled radiological inventory for the projected period (1994–2003) was compared to the waste generator forecasts. Because the waste generator forecasts were the starting point for evaluating the projected waste, the close agreement with reported estimates in CIDRA is not surprising. As expected and consistent with the assumptions, the best-estimate CIDRA values (after the bias corrections and other refinements are applied) differ substantially from the generator forecasts.

- As a final confirmation of its substantial completeness, the recent inventory (1984–1993) of contaminants was compared against the list of contaminants detected in environmental monitoring at the RWMC. The historical inventory (1952–1983) was also included in the comparison. No radiological contaminants were reliably detected in the monitoring that had not been identified in either the historical or the recent inventories. The only nonradiological contaminants detected more than rarely in the environmental monitoring that were not identified in the inventories were three volatile organic compounds: 1,1-dichloroethylene, 1,1-dichloroethane, and dichlorodifluoromethane. These three contaminants may be degradation products or impurities associated with closely related contaminants that were identified in the historical inventory. Detected contaminants also could have originated from sources other than the subject waste (e.g., in effluents from other INEL facilities or from other waste at the RWMC).

- A large quantity of information was assembled and entered into CIDRA on the physical and chemical forms of the waste streams and of the contaminants, and on the packaging of the waste streams.

- Even though the information now residing in CIDRA has been through multiple checks and reviews, the possibility exists for oversights and discrepancies. In addition, new information about the waste is identified from time to time in other INEL programs. As new information is discovered, the database will be revised as necessary.

ACRONYMS AND ABBREVIATIONS

AEC	U.S. Atomic Energy Commission
ALE	Argonne National Laboratory–East
ANL-E	Argonne National Laboratory–East
ANL-W	Argonne National Laboratory–West
ANP	Aircraft Nuclear Propulsion (Program)
ARA	Auxiliary Reactor Area
ARMF	Advanced Reactivity Measurement Facility
ARVFS	Army Reentry Vehicle Area
ATR	Advanced Test Reactor
ATRC	Advanced Test Reactor Critical
BAD	Best Available Data (database)
BDL	below detection limit
BNL	Battelle Northwest Laboratories
BORAX	Boiling Water Reactor Experiment
BRA	baseline risk assessment
CAS	Chemical Abstract Services
CEG	Combustion Engineering—General Atomics
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CIDRA	Contaminant Inventory Database for Risk Assessment
CTF	Containment Test Facility

CWS	Chemical Warfare Service
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
EBR	Experimental Breeder Reactor
ECF	Expended Core Facility
EFL	Experimental Fuels Laboratory
EMU	Environmental Monitoring Unit
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
ER	environmental restoration
ERP	environmental restoration projects
ETR	Engineering Test Reactor
ETRC	Engineering Test Reactor Critical
FCF	Fuel Cycle Facility
FFA/CO	Federal Facility Agreement and Consent Order
FMF	Fuel Manufacturing Facility
G-M	Geiger-Müller
GCRE	Gas-Cooled Reactor Experiment
HDT	historical data task
HEPA	high-efficiency particulate air
HFEF	Hot Fuel Examination Facility
HTRE	Heat Transfer Reactor Experiment
ICPP	Idaho Chemical Processing Plant
IET	Initial Engine Test (Facility)

IFR	Integral Fast Reactor
INEL	Idaho National Engineering Laboratory
LLW	low-level waste
L&O	Laboratory and Office Building
LOF	Loss of Fluid (Test Reactor)
LOFT	Loss of Fluid Test (Reactor)
MAP	mixed activation products
MFP	mixed fission products
ML-1	Mobile Low-Power Reactor No. 1
MTA	Mobile Test Assembly
MTR	Materials Test Reactor
NCP	National Contingency Plan
ND	not detected
NOS	not otherwise specified
NR	not reported
NRC	U.S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility
NRP	Naval Reactors Program
NRTS	National Reactor Testing Station
NWCF	New Waste Calcining Facility
OECD	Organization for Economic Cooperation and Development
OFF	offsite waste generators not otherwise specified
PA	performance assessment
PBF	Power Burst Facility

PCB	polychlorinated biphenyl
PCS	Primary Coolant System
PER	Power Excursion Reactor
PM	Portable Medium Nuclear Power Plant
PQL	practical quantitation limit
RCRA	Resource Conservation and Recovery Act
RESL	Radiological and Environmental Sciences Laboratory
RFP	Rocky Flats Plant
RI/FS	remedial investigation/feasibility study
RLWTF	Radioactive Liquid Waste Treatment Facility
RMF	Reactivity Measurements Facility
RML	Radiation Measurements Laboratory
RPDT	recent and projected data task
RPSSA	Radioactive Parts Security Storage Area
RSD	relative standard deviation
RSWF	Radioactive Scrap and Waste Facility
RWMC	Radioactive Waste Management Complex
RWMIS	Radioactive Waste Management Information System
SCMS	Sodium Components Maintenance Shop
SDA	Subsurface Disposal Area
SDS	Submerged Demineralizer System
SHADE	shielded hot air drum evaporator
SL-1	Stationary Low-Power Reactor No. 1
SLSF	Sodium Loop Safety Facility
SMC	Specific Manufacturing Capability

SNAP	Systems for Nuclear Auxiliary Power
SNAPTRAN	Space Nuclear Auxiliary Power Transient
SPERT	Special Power Excursion Reactor Test
SPF	Sodium Process Facility
SRE	Sodium Reactor Experiment
SS	special study
TAN	Test Area North
TMI	Three-Mile Island
TRA	Test Reactor Area
TREAT	Transient Reactor Test (Facility)
TRU	transuranic
TSA	Transuranic Storage Area
TSF	Technical Support Facility
UCL	upper confidence limit
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAG	waste area group
WERF	Waste Experimental Reduction Facility
WIPP	Waste Isolation Pilot Plant
WMC	Waste Management Complex
WRRTF	Water Reactor Research Test Facility
ZPPR	Zero Power Physics Reactor

REGULATORY SOURCES CITED

DOE Orders

DOE Order 5820.2A, "Radioactive Waste Management," September 26, 1988

Codes of Federal Regulation

Code of Federal Regulations, 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Wastes"

Code of Federal Regulations, 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan"

Statutes

Atomic Energy Act

Clean Air Act

Clean Water Act

Comprehensive Environmental Response, Compensation, and Reliability Act (CERCLA)

Federal Water Pollution Control Act

National Environmental Policy Act

Resource Conservation and Recovery Act (RCRA)

Safe Drinking Water Act

Solid Waste Disposal Act

Toxic Substances Control Act

Agreements

Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory, signed December 9, 1991